Direct observation of 1000m deep convection in the Irminger Sea by ARGO-O_2 floats during winter 2011-2012

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1. Summary

Using ARGO float data, we describe here an intense deep convection event, covering a large area in the Irminger Sea during winter 2011-2012

2. Past observations of deep convection in the Irminger basin: limited in space and time

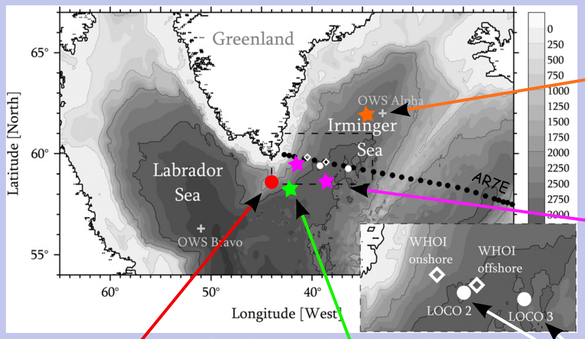


Figure 1 from de Jong et al., 2012 (DSR1)

Våge et al., 2008 (Nature Geosci.)
MLD 1000m
(April 2008)

Bacon et al., 2003 (GRL)
MLD 700m and 1000m
(August-September 1997)

● vertical profiles homogeneous from the surface
★ vertical profiles with surface stratification

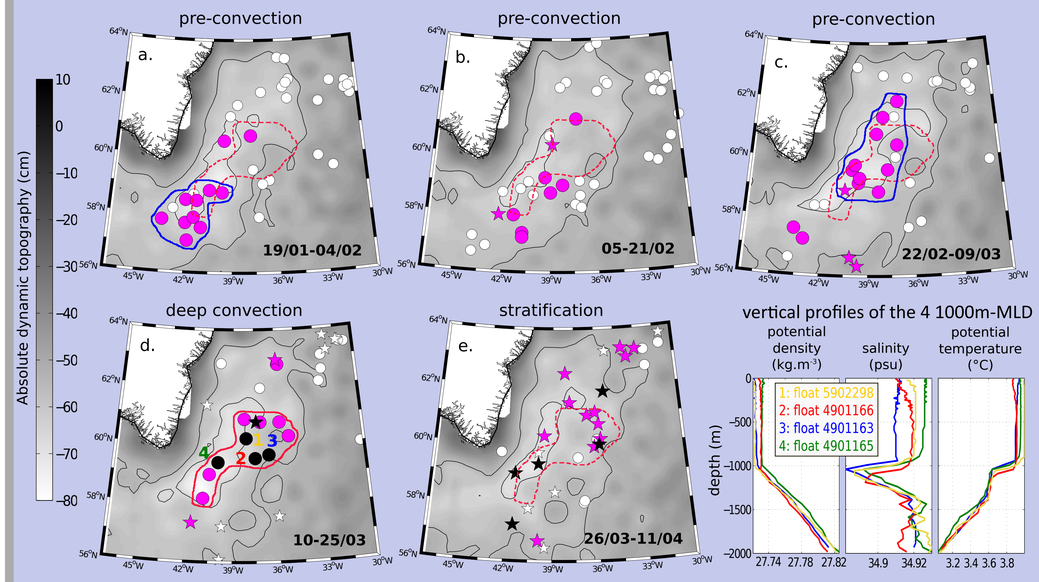
Bacon et al., 2003 (GRL)
MLD 900-1000m
(March 1997)

Pickart et al., 2003 (DSR1)
MLD 1800m
(April 1991)

de Jong et al., 2012 (DSR1)
MLD > 800m at LOCO2 and LOCO3
(winters 2007-08 and 2008-09)

Past observations of deep convection were generally obtained after summer restratification

3. Observation of the 2011-2012 convective event with ARGO data



***Shade**: mean absolute dynamic topography from AVISO products (contours -65cm and -55cm)*

***Colored symbols**: Mixed Layer Depth (MLD) calculated from ARGO floats vertical profiles with the de Boyer Montégut et al., 2004 (JGR) treshold method (Δσ=0.01kg.m-3) and with the Thomson and Fine, 2003 (AMS) split-and-merge method and controlled by visual inspection.*

***White**: MLD < 680m*
***Magenta**: MLD > 680m*
***Black**: MLD at about 1000m*

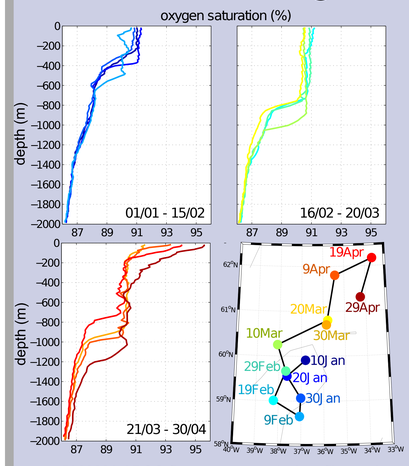
***Dots**: MLD without surface stratification*
***Stars**: MLD with surface stratification*

***Colored numbers**: indicate the float-numbers of 1000m-MLD.*

***Blue contour** in fig. a, b, c: convection area during pre-convective phase.*
***Red contour** in fig. d: deep convection area reported over fig. a, b, c, e with **red dashed-line**.*

The convection event spreads over such great domain! We identify:
- a pre-convective phase from 19 January to 9 March, 2012 (9.5 weeks) with different pre-convective areas
- a short deep convection phase between 10 and 25 March, 2012 reaching 1000m depth
- a rapid restratification in some days after 25 March, 2012

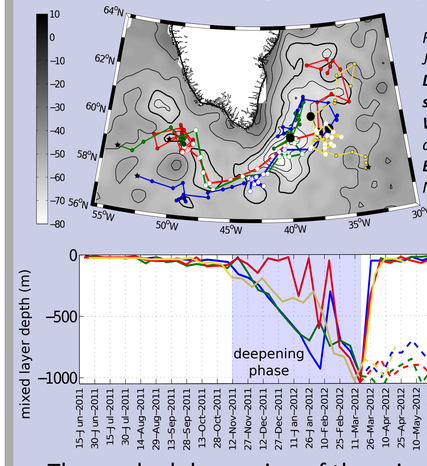
4. Active mixing



5902298 ARGO float oxygen vertical profiles and trajectory, between 1 January and 30 April, 2012

ARGO oxygen data highlight an active mixing

5. Mixed layer deepening



*Floats trajectories between 15 June 2011 and 9 July, 2012; **Dots**: all float positions; **Black stars**: beginning of trajectories; **White dots**: float positions during MLD deepening phase; **Black dots:** position of 1000m-MLD.*

***Lines**: mixed layer depth along float trajectories*
***Dashed-lines:** depth of the mixed layer under a near-surface stratified layer*

The gradual deepening of the mixed layer from November, 2011 to March, 2012 is marked by:
- a short restratification period early February
- a late rapid deep convective activity (10-16 March)

6. Link to atmospheric forcings

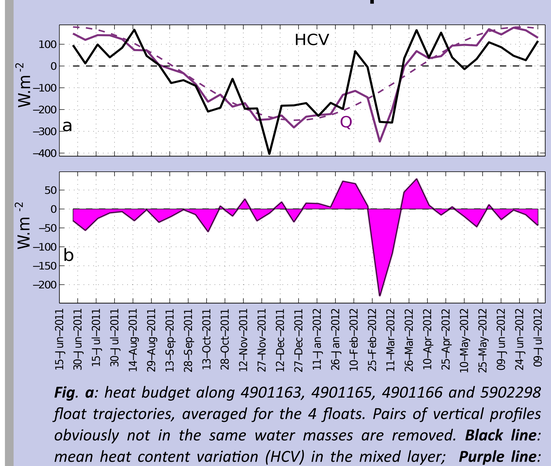


***Fig. a**: heat budget along 4901163, 4901165, 4901166 and 5902298 float trajectories, averaged for the 4 floats. Pairs of vertical profiles obviously not in the same water masses are removed. **Black line**: mean heat content variation (HCV) in the mixed layer; **Purple line**: mean ERA-Interim net air-sea heat fluxes (Q); **Purple dashed-line**: sinusoidal approximation of the Q-curve*

***Fig. b:** air-sea heat fluxes anomalies relative to the sinusoidal approximation*

- Air-sea heat fluxes explain at the first order the heat content variation in the mixed layer and the gradual deepening of the MLD from November, 2011 to March, 2012.
- Reduced heat loss end of January/early February explains the observed short restratification phase during this period.
- The deepening of the MLD up to 1000m is caused by a late event of intense heat loss occuring between mid-February and mid-March, 2012 linked to high NAO-index caracterized by strong winds and successive low-pressures over the Irminger Sea (not shown here).

Conclusion: this study presents the first direct observation of much widespread deep convection in the Irminger Sea than ever observed before, thanks to several ARGO floats cruising in the area.

REFERENCES:
- **Bacon et al., 2003** (GRL), doi: 10.1029/2002GL016271
- **de Boyer Montégut et al., 2004** (JGR), doi: 10.1029/2004JC002378
- **de Jong et al., 2012** (DSR1), doi: 10.1016/j.dsr.2012.01.003
- **Thomson and Fine, 2003** (AMS), doi: 10.1175/1520-0426 (2003)020<0319:EMLDFO>2.0.CO;2
- **Pickart et al., 2003** (DSR1), doi: 10.1016/S0967-0637(02)00134-6
- **Våge et al., 2008** (Nature Geosc.), doi: 10.1038/NGEO382

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